SOLAR INDICES BULLETIN

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♦ SOLAR RADIO EMISSIONS

The quiet Sun emits radio energy with a slowly varying intensity. These radio fluxes, which stem from atmospheric layers high in the chromosphere and low in the corona, change gradually from day-to-day, in response to the number and size of spot groups on the solar disk. The table below gives daily measurements of this slowly varying emission at selected wavelengths between about 1 and 100 centimeters. Many observatories record quiet-sun radio fluxes at the same local time each day and correct them to within a few percent for factors such as antenna gain, bursts in progress, atmospheric absorption, and sky background temperature. At 2800 megahertz (10.7 centimeters) flux observations summed over the Sun's disk have been made continuously since February 1947.

♦ SOLAR FLUX TABLE

Numbers in parentheses in the column headings below denote frequencies in megahertz. Each entry is given in solar flux units--a measure of energy received per unit time, per unit area, per unit frequency interval. One solar flux unit equals 10^{-22} $J/m^2 Hz sec$.

During low periods of solar activity, the flux never falls to zero, because the Sun emits at all wavelengths with or without the presence of spots. The lowest daily Ottawa flux since 1947 occurred on November 3, 1954. On that day the observed noon value dropped to 62.6 units; the highest observed value of 457.0 occurred on April 7, 1947.

The preliminary observed and adjusted Penticton fluxes tabulated here are the "Series C" values reported by Canada's Dominion Radio Astrophysical Observatory in Penticton, British Columbia. Observed numbers are less refined, since they contain fluctuations as large as ±7% from the continuously changing sun-earth distance. Adjusted fluxes have this variation removed; they show the energy received at the mean distance between the Sun and Earth. Gaps in the Learmonth, Australia (LEAR) data reflect equipment problems. Fluxes measured either at Palehua on the Hawaiian Islands, or at San Vito, Italy, will be substituted for frequencies at which many Learmonth values are missing.

OCTOBER 1998 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number Intl	Obs Flux Pentic (2800)	Solar Flux Adjusted to 1 Astronomical Unit LEAR (15400)	LEAR (8800)	LEAR (4995)	Pentic (2800)	LEAR (2695)	LEAR (1415)	LEAR (610)	LEAR (410)	LEAR (245)
01	30	119	---	---	---	119	---	---	---	---	---
02	32	113	554	243	153	113	117	92	43	31	12
03	22	112	556	241	147	112	110	89	41	31	13
04	19	115	556	244	152	115	111	91	41	31	12
05	28	117	---	---	---	117	---	---	---	---	---
06	66	117	---	---	---	117	---	---	---	---	---
07	66	124	553	240	154	124	116	91	46	33	15
08	86	124	553	245	158	124	120	93	48	34	17
09	89	124	555	246	161	124	121	95	37	27	11
10	60	121	---	---	---	121	---	---	---	---	---
11	51	119	555	240	157	119	118	91	---	---	---
12	45	114	560	241	153	114	116	90	32	24	9
13	48	118	561	240	151	117	116	89	36	29	12
14	66	119	567	242	153	118	115	90	37	30	14
15	77	131	562	242	156	130	115	91	38	38	12
16	93	131	562	250	166	130	128	99	38	44	54
17	98	135	564	251	169	134	131	99	---	---	22
18	99	126	570	251	169	125	129	98	42	43	---
19	96	118	560	244	161	117	120	92	39	32	17
20	76	121	567	249	156	120	118	90	38	32	17
21	68	118	562	242	156	117	120	93	39	32	12
22	49	115	568	247	154	114	118	88	40	34	13
23	50	113	558	242	148	112	109	87	52	36	15
24	39	111	564	234	147	110	110	86	51	37	21
25	29	108	558	240	148	107	109	86	52	40	---
26	35	104	---	229	141	103	103	80	49	39	16
27	23	103	545	233	141	102	101	78	52	37	17
28	23	108	558	234	141	107	101	78	54	45	20
29	54	110	557	237	144	108	105	83	54	40	18
30	54	112	568	241	147	110	107	85	56	40	17
31	52	119	---	242	147	117	110	86	54	37	16
Mean	56	117	560	242	153	117	115	89	44	35	17

SEP 1998 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	177.0	180.2
02	163.4	166.3
03	162.7	165.5
04	154.7	157.3
05	154.3	156.8
06	164.6	167.1
07	151.2	153.5
08	153.5	155.8
09	145.3	147.4
10	141.7	143.6
11	138.6	140.4
12	134.9	136.6
13	130.7	132.3
14	121.8	123.3
15	117.3	118.6
16	118.7	119.9
17	117.4	118.6
18	122.5	123.7
19	126.9	128.0
20	132.1	133.3
21	138.3	139.4
22	141.1	142.1
23	143.2	144.1
24	135.4	136.2
25	138.5	139.2
26	135.6	136.2
27	127.4	128.0
28	122.5	123.0
29	115.9	116.3
30	121.5	121.8
Mean	138.3	139.8

♦ SUNSPOT COUNTS

In 1848 the Swiss astronomer Johann Rudolph Wolf introduced a daily measurement of sunspot number. His method, which is still used today, counts the total number of spots visible on the face of the Sun and the number of groups into which they cluster, because neither quantity alone satisfactorily measures the level of sunspot activity.

An observer computes a daily sunspot number by multiplying his estimated number of groups by ten and then adding this product to his total count of individual spots. Results, however, vary greatly, since the measurement strongly depends on observer interpretation and experience and on the stability of the Earth's atmosphere above the observing site. Moreover, the use of Earth as a platform from which to record these numbers contributes to their variability, too, because the sun rotates and the evolving spot groups are distributed unevenly across solar longitudes. To compensate for these limitations, each daily international number is computed as a weighted average of measurements made from a network of cooperating observatories. The international sunspot numbers tabulated on page 1 are provisional values taken from a bulletin prepared monthly by Pierre Cugnon of the SUNSPOT INDEX DATA CENTER, 3 avenue Circulaire, B-1180 BRUXELLES, BELGIUM. The August 1998 data combine observations from 34 stations. http://www.oma.be/KSB-ORB/SIDC/index.html.

♦ HISTORICAL SUNSPOT COUNTS

How do sunspot numbers in the table on page 1 compare to the largest values ever recorded? The highest daily count on record occurred December 24-25, 1957. On each of those days the sunspot number totaled 355. In contrast, during years near the spot cycle minimum, the count can fall to zero. Today, much more sophisticated measurements of solar activity are made routinely, but none has the link with the past that sunspot numbers have. Our archives, for example, include reconstructed daily values from January 8, 1818; monthly means from January 1749; and yearly means beginning in 1700.

SMOOTHED (OBSERVED AND PREDICTED) SUNSPOT NUMBERS: CYCLES 22 AND 23

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1988	58	65	71	78	84	94	104	114	121	125	130	138	98
1989	142	145	150	154	157	158	159	158	157	157	158	154	154
1990	151	153	152	149	147	144	141	141	142	142	142	144	146
1991	148	148	147	147	146	145	146	147	145	142	138	132	144
1992	124	115	108	103	100	97	91	84	80	76	74	73	94
1993	71	69	67	64	60	56	55	52	48	45	41	38	56
1994	37	35	34	34	33	31	29	27	27	27	26	26	30
1995	24	23	22	21	19	18	17	15	13	12	11	11	17
1996	10	10	10	9	8*	9	8	8	8	9**	10	10	9
1997	10	11	14	17	18	20	23	25	28	32	35	39	23
1998	44	49	54	57	62	68	74	81	88	94	100	104	73
					(3)	(6)	(8)	(10)	(12)	(14)	(17)	(19)	(7)
1999	109	113	116	122	127	132	135	138	140	144	147	149	131
	(22)	(23)	(22)	(22)	(22)	(23)	(25)	(28)	(31)	(34)	(36)	(39)	(27)
2000	149	149	150	150	148	147	145	145	144	142	140	137	146
	(42)	(45)	(46)	(48)	(48)	(47)	(46)	(46)	(46)	(46)	(46)	(46)	(46)

*May 1996 marks Cycle 22's mathematical minimum.
**October 1996 marks the consensus Cycle 22 minimum which NGDC is now using.

♦ SUNSPOT NUMBER PREDICTIONS

For the end of Solar Cycle 22, and the beginning of Cycle 23, the table gives smoothed sunspot numbers up to the one calculated that first uses the most recently measured monthly mean. These smoothed, observed values are based on final, unsmoothed monthly means through June 1998 and on provisional ones thereafter. We compute a smoothed monthly mean by forming the arithmetic average of two sequential 12-month running means of monthly means.

Table entries with numbers in parentheses below them denote predictions by the McNish-Lincoln method. This method estimates future numbers by adding a correction to the mean of all cycles that is proportional to the departure of earlier values of the current cycle from the mean cycle. (See page 9 in the July 1987 supplement to *Solar-Geophysical Data*). We use and predict only smoothed monthly means, because we believe the errors are too great to estimate any values more precise. In the table above, adding the number in parentheses to the predicted value generates the upper limit of the 90% confidence interval; subtracting the number from the predicted value generates the lower limit. Consider, for example the April 1999 prediction. There exists a 90% chance that in April 1999 the actual smoothed sunspot number will fall somewhere between 100 and 144.

The McNish-Lincoln prediction method generates useful estimates of smoothed, monthly mean sunspot numbers for no more than 12 months ahead. Beyond a year these predictions regress rapidly toward the mean of all 13 cycles used in the computation. Moreover, the method is very sensitive to the date defined as the beginning of the current sunspot cycle, that is, to the date of the most recent sunspot minimum. The new cycle predictions tabulated above are based on the consensus minimum value of 8.8 that occurred in October 1996. For solar maximum discussions, visit http://www.sec.noaa.gov.